Human Systems Integration (HSI) in User-System Interface (USI) Development for Complex Information-Based Systems

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The Boeing Company

Outline

- **Background**
- **Overview**
- **Key Elements**
  - **Organization**
  - **Requirements**
  - **Standards**
  - **Multi-Disciplinary USI task team & process**
  - **Risk-driven design and prototyping**
  - **Collaborative test and evaluation**
- **Summary**

Customer (Military Service) HSI Initiative

DoD: Reissued DODD 5000.1, requiring PMs to apply HSI

Reissued DODI 5000.2 that defines HSI domains and provides guidance regarding PM's responsibilities

USAF: HSI Implementation study planned for 2004

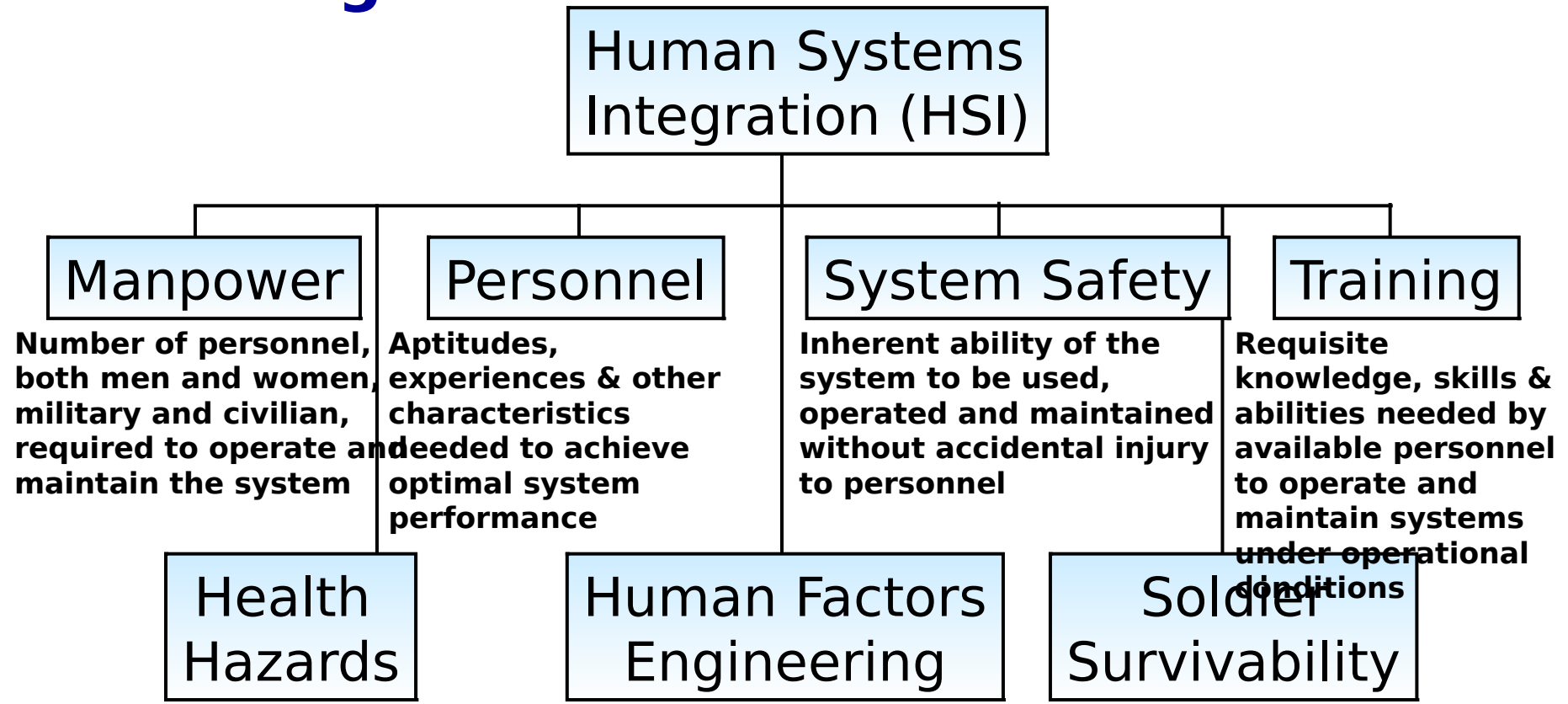
Navy: NAVSEA established SEA-03 Human Systems Directorate (several initiatives underway)

Space and Warfare Systems Command established HQ HSI office in Sand Diego

NAVAIR established HSI Management Board

Army: Continued active MANPRINT involvement in major acquisition programs (e.g. Future Combat

Traditional Human Systems Integration


Human Systems Integration (HSI)
Manpower
Number of personnel, both men and women, military and civilian, required to operate and maintain the system
Personnel
Aptitudes, experiences & other characteristics needed to achieve optimal system performance
System Safety
Inherent ability of the system to be used, operated and maintained without accidental injury to personnel
Training
Requisite knowledge, skills & abilities needed by available personnel to operate and maintain systems under operational conditions
Health Hazards
Inherent conditions in the operation of a system that could cause death, injury, illness, disability or reduce job performance or personnel
Human Factors Engineering
Integration of human character-istics into system definition, design, development and eval-uation to optimize performance of human-machine combinations
Soldier Survivability
Characteristics of a system that can reduce soldier detectability; prevent attack if detected; prevent damage if attacked; minimize medical injury if wounded; and reduce physical and mental fatigue.

"Facilitating Cooperation Between Human Systems Integration (HSI) and Information Systems (IS) Communities"

-- **DoD Workshop:** Hosted by M.I.T. Lincoln Laboratories, July 2001

-- **Sponsors:** OSD Directors of Bio-Systems and Information Systems

Conclusions: "The marketplace definition of software now is that it must be both functional and useful." ***- Dr. Robert Foster***

OSD Director, Bio Systems

Narrowing of differences between how HSI & IS define "success" may help better align their efforts.

"DoD S&T communities should be committed to improving the design and development of C² Decision Support systems. Once this is accomplished, it is important then to continue advocating HS/IS collaboration at the highest levels of the Defense

Overview

- Balanced emphasis on HSI domains best suited to traditional weapon systems, such as fixed wing & rotary wing aircraft, ships, tanks, etc.

- In complex, information-based systems (e.g., C⁴ISR), some HSI domains demand more or less attention. Relationships with certain non-HSI domains (such as software engineering) must be strengthened.

- Increased Human Systems Integration/Information Systems (HSI/IS)

  collaboration is being stressed by DoD, especially for C⁴ISR.

- Good HSI / IS collaboration (as well as collaboration between HSI domains) improves quality, consistency and usability of systems.

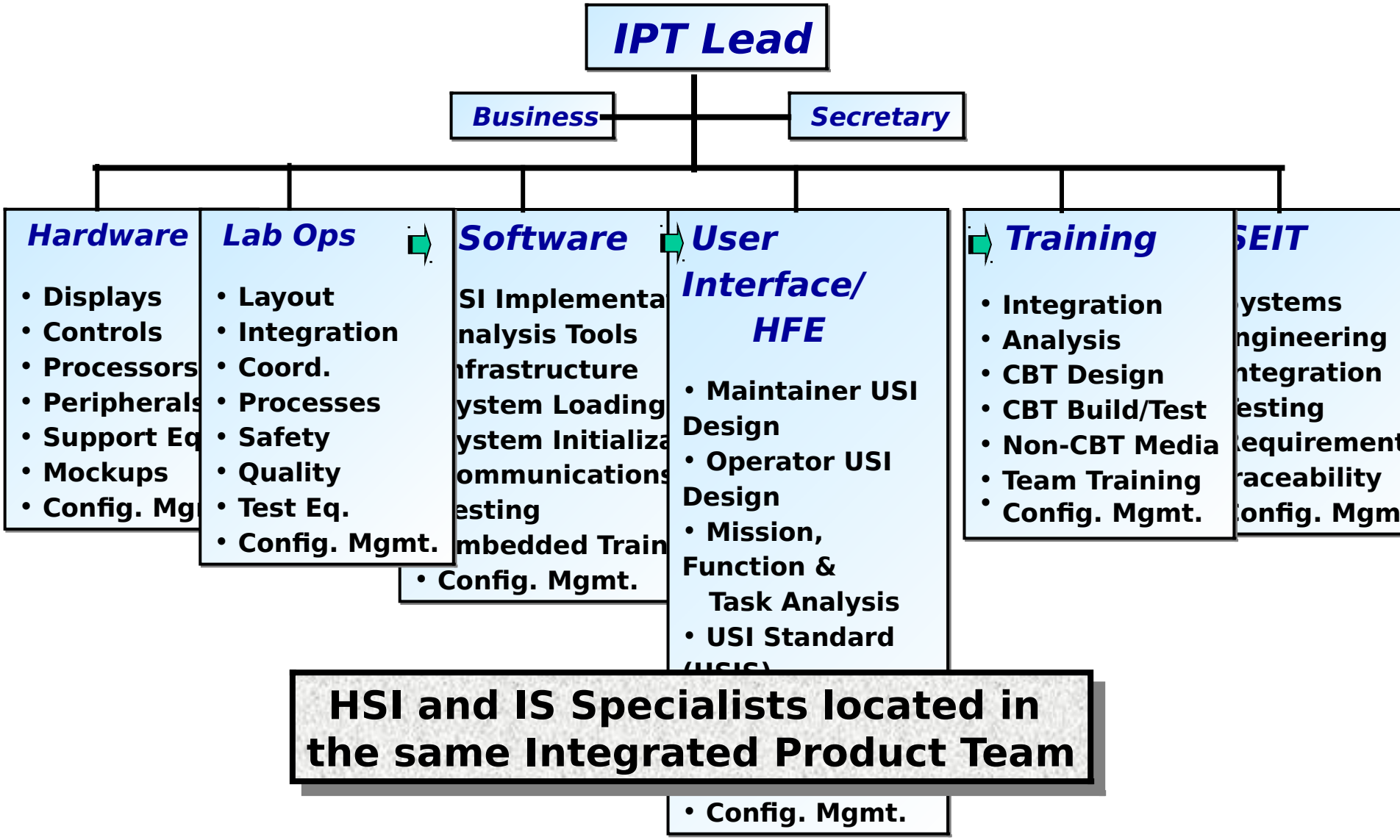
Example Boeing Activity - Highlights

- Complex, Object-Oriented System (> 1+ million SLOC) integrated with several COTS software packages in a layered architecture.
- All user interfaces, more than 300 GUI screens & operator procedures, developed in 19 months. Completed 100% of USI design by CDR.
- Developed, demonstrated & evaluated 18 USI interactive prototypes.
- Manpower, Personnel, Habitability & Health Hazards pre-defined.
- Significant USI Development (about 50,000 labor hours, 55 people)
- HSI Goals:
  - Robust system functionality / ease of system usability
  - Minimized workload and fatigue
  - Enhanced operator situational awareness (SA)

Key Elements of USI Process

- ✓ HSI, SEIT & IS disciplines in the same IPT – at the same level
- ✓ USI goals/objectives translated into specific, verifiable requirements
- ✓ USIS available early & strictly enforced
- ✓ HSI support to USI development before & after CDR (design freeze)
- ✓ USI process integrates HSI, IS, SEIT & End-Users
- ✓ Common USI Scenario used by all design personnel
- ✓ Standard USI design / procedure brief & checklist **(to assure completeness & consistency)**
- ✓ Risk-driven USI development scheduling and prototyping
- ✓ Collaborative HSI / IS test, evaluation and demo of user interfaces
- ✓ Personnel workforce stability **(contractor, customer, end-users)**

Integrated Product Team (IPT) Organization



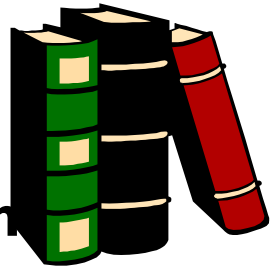
USI Implementation Goals

Features implemented to enhance usability:

- Context-driven automatic data handling
- Data entry and other defaults
- Positive feedback
- Display declutter options
- Group symbol manipulation
- Three action limit for high priority (frequently used, time-critical) operations
- Four level limit for selection menus
- The same USI conventions applied to the design of displays and controls across modes, windows, screens and stations (enforced by adherence to USI Std.)
- Alert decision aids

- **Important to have specific (verifiable) goals.**
- **Documented if possible.**

User-System Interface Standard (USIS)



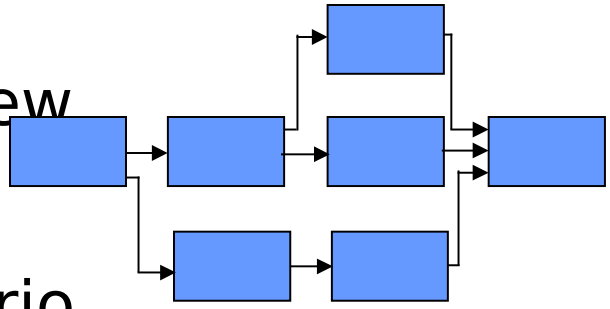
- Addressed all hardware & software-based USI.
- Addressed both operator and maintainer requirem
- Based on multiple references & tailored to program needs, e.g.,
  - Motif Style Guide
  - Joint Technical Architecture / TAFIM VIII Style Guide
  - User Interface Specification for the Defense Information Infrastructure (DII)
  - MIL-STD-1472, Human Engineering Design Criteria for Military Systems, Equipment and Facilities
  - MIL-HDBK-46855, Human Engineering Program Process and Procedures
  - Electronics Industry Association (EIA) [illegible] HEB-1
  - MIL-STD-2525B, Common Warfighting Symbology
  - Others (Government and Non-Government

Key Document

Joint HSI/IS USI Activities

- User interface development
- Use case evaluation
- USI Design Brief development and coordination
- Static & interactive prototype evaluation
- Scenario-based user interface evaluation

Human Factors Engineering USI Activities



- Conduct mission, crew function, crew role, task and workload analysis
- Develop comprehensive USI Scenario
- Develop & enforce USIS and USI design checklist
- Develop USI design/procedure briefing requirements
- Chair internal design coordination meetings & customer reviews
- Provide consultation to SW design teams regarding USIS application
- Provide operator station mockup support (hardware USI)

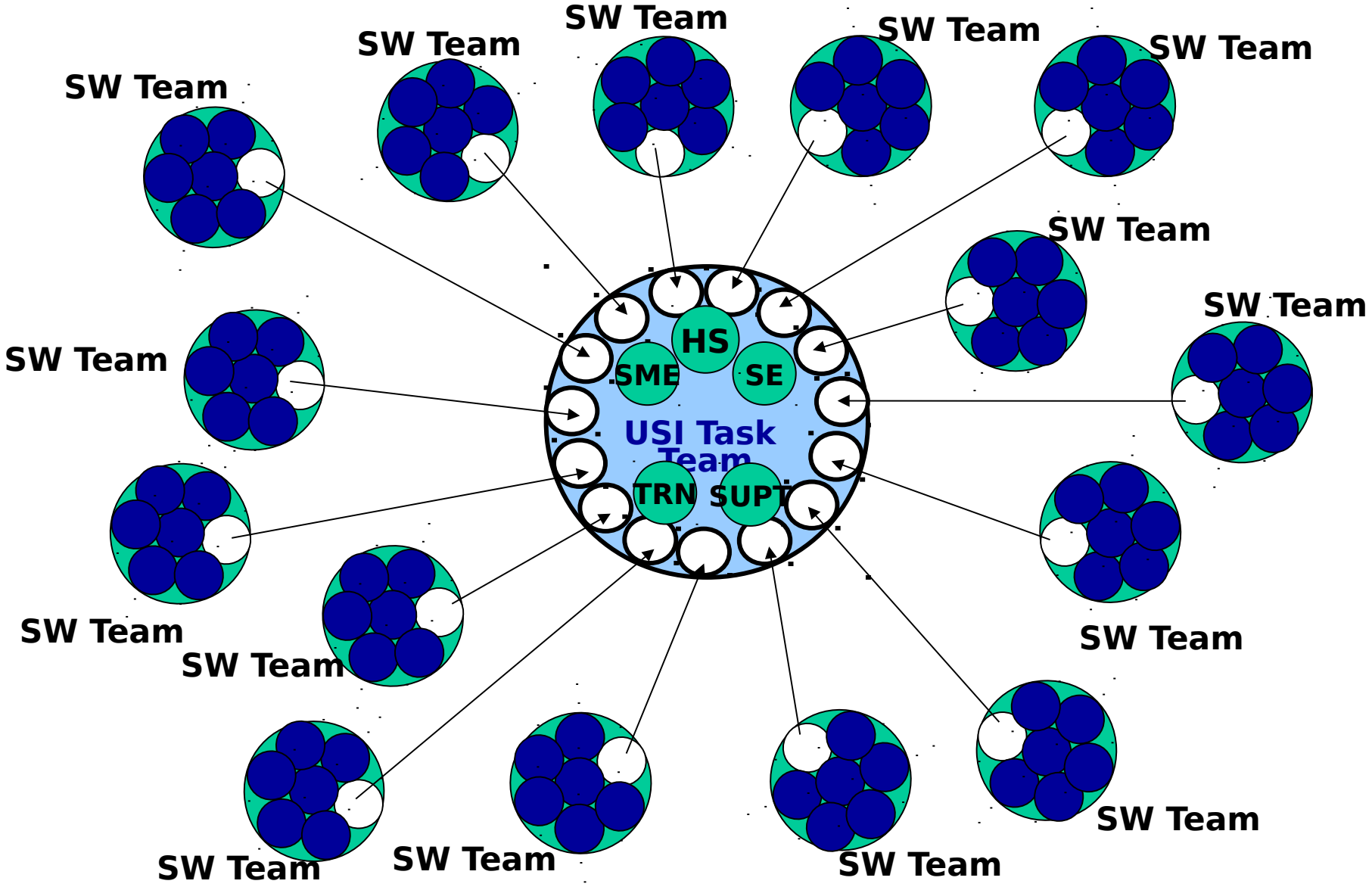
Information Systems (IS) USI Activities

- Flow down of system/sub-system specifications to Software Requirements Specification (SRS)
- Lead development of use cases
- Author USI design/procedure briefings
- Develop user interface GUI prototypes
- Design and code user-system interfaces
- Conduct low-level USI software testing

Operator Training USI Activities

- Participate in USI development by identifying design impacts on training
- Perform detailed operator task and learning analyses
- Participate in USI test and evaluation
- Author / develop training on system design, operation and employment

USI Task Team



USI Multi-Discipline Top-Level Process

1. **Develop** USI layout, appearance & mechanization for logically- related groupings of user interfaces in accordance with USIS and assemble into a standardized design/procedure brief.

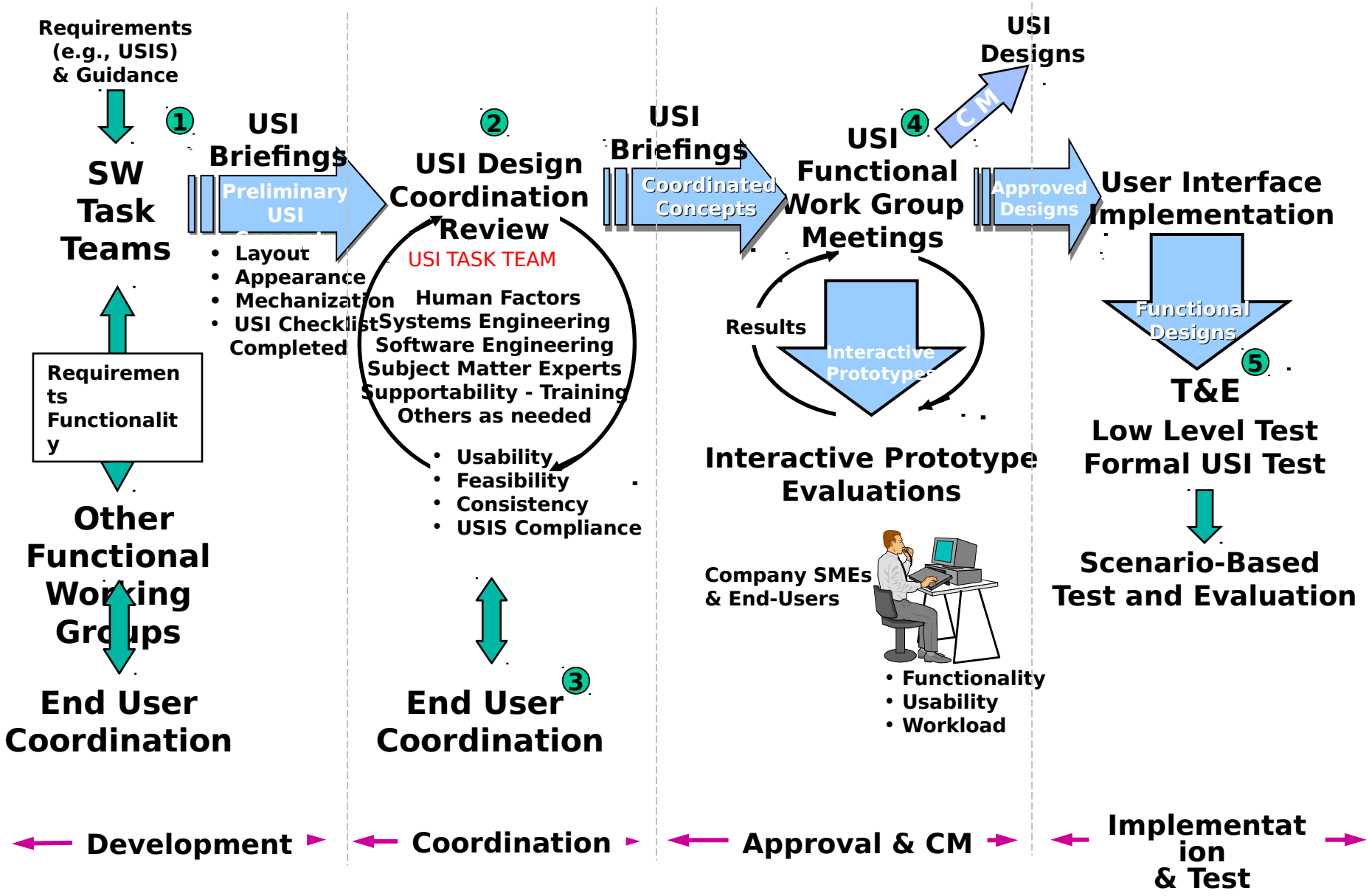
2. **Present** the USI to the internal Design Coordination Team (developers-only). Revise as needed for USIS compliance.

3. **Coordinate** the USI with end users until agreement is reached. Revise as needed.

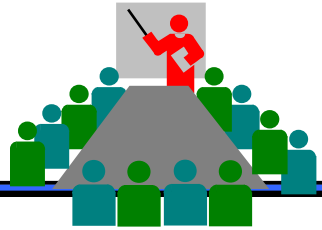
4. **Formally Present** the USI to the USI Functional Work Group (developers & customers), secure approval (develop & evaluate dynamic prototypes as needed) and CM.

5. **Test and evaluate** USI to verify functionality &

Integrated HSI/IS User Interface Development Process



USI Briefings



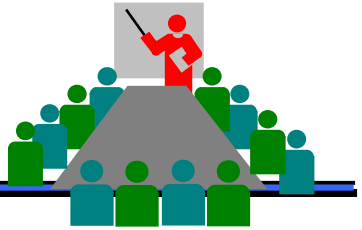
1) **Describe the capabilities addressed by the briefing - not in terms of individual SRS requirements, but generally what system capabilities and crew functions are addressed. Also, identify any assumptions and/or preconditions for the capabilities being addressed. (HSI/IS)**

2) **Using the "USI Prototyping Scenario," identify the mission phases, events, and functions relevant to the briefing. (HSI)**

3) **Describe the layout (functional groupings, arrangement) of each window & cue and provide rationale/explanation as necessary. Show the cue size in relation to the overall desktop and where the cue will appear. (IS)**

4) **Identify the purpose and provide a description of each display element on each cue. For data entry fields, explain any alternative means of accomplishing entry of the data, if any (such as clicking on the Tacplot versus typing in the Lat/Long field). (IS)**

USI Briefings



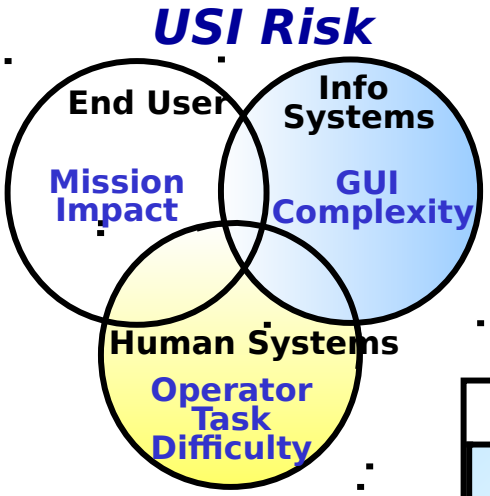
5) **Identify the purpose and provide a description of each control on each cue down to the button-pushing level (e.g., when X is pushed, Y happens). Identify alternative methods of accomplishing the function(s) if any. Mention and briefly describe possible selection options not addressed in the mini-scenario. (IS)**

6) **Describe the the mini-scenario(s) selected to demonstrate the USI and the functionality behind the GUI with emphasis on the operator's functions. Clearly differentiate operator roles if more than one operator is involved. One or more scenario should be used to fully illustrate the functionality being described. (IS)**

7) **Describe the step-by-step operator decisions and actions involved in accomplishing the mini-scenario(s) in the context of the GUI screens. PowerPoint Notes should be used to describe the sequence of steps an operator would take to accomplish the functions. (HSI/IS)**

8) **Identify any HS or IS Issues. (HSI/IS)**

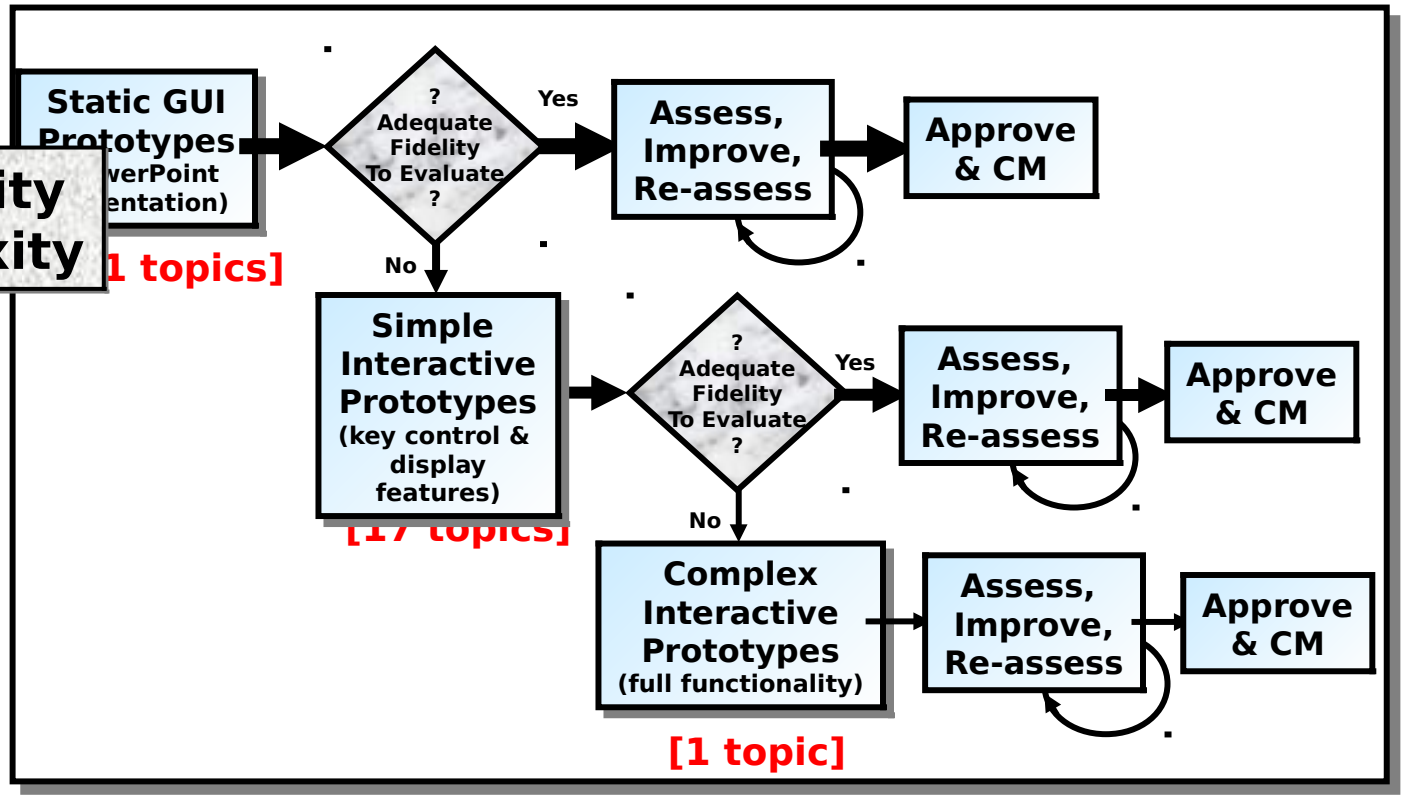
Risk-Driven Design & Prototyping



Impact

- **Scheduling of USI design/procedure briefs (before or after Preliminary Design Review)**
- **Prototype fidelity/complexity**

USI Complexity ≠ IS Complexity



USI Testing

- **Window Low-Level Tests (IS) (widget level)**
- **User Interface Formal Test (HSI)**
- **Scenario-Based Usability Assessment / Demonstration (H**
  - Realistic Evaluation Scenarios
  - Operator questionnaires embedded into test procedures
  - Deficiency Documentation and Resolution (AIs)
  - Rapid Fix and Verification by End-Users

Workstation & Laboratory Assessments

HFE / IS <--> Operator Training Synergy

- Training Support at all USI Design Reviews
- USI mission scenarios, crew role definitions, crew task analyses & USI design/procedure briefings provided to training
- Detailed training operator task analyses provided as inputs to USI test procedures
- HS/IS personnel acted as Subject Matter Experts (SME) for stand-up training and CBT development

USI Goals vs. Results

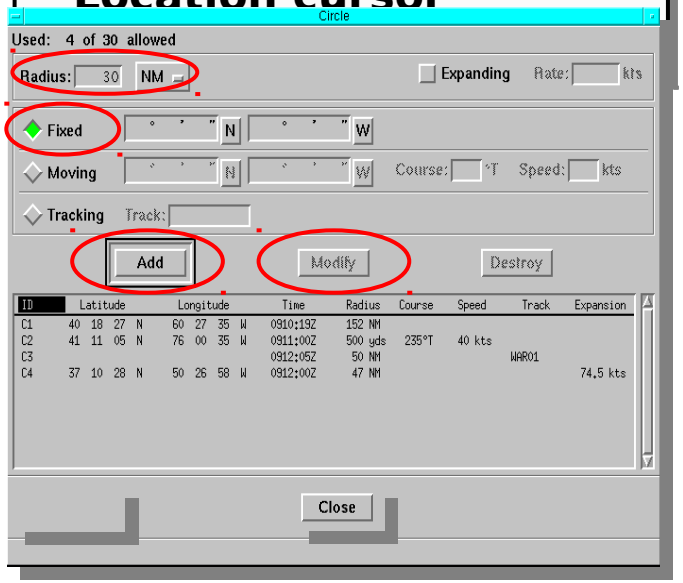
Goal:

Minimize Operator Actions & Fatigue

System Spec

- **Context driven automatic data handling Implemented**
- **Data entry defaults 1,340 Defaults**
- **Positive feedback Implemented**
- **Display declutter options Implemented**
- **Group symbol manipulation Implemented**
- **3-action limit for high priority Implemented (frequently used, time critical) ops**
- **Four level limit for selection menus Implemented**
- **Same USI conventions applied to the**

- **“Smart,” context-driven defaults**
- **Data entry defaults (e.g., time, date, data)**
- **Pre-selected tabs & settings**
- **Grayed-out options (when not available)**
- **Reduced workload**
- **Reduced task time**
- **Location cursor**



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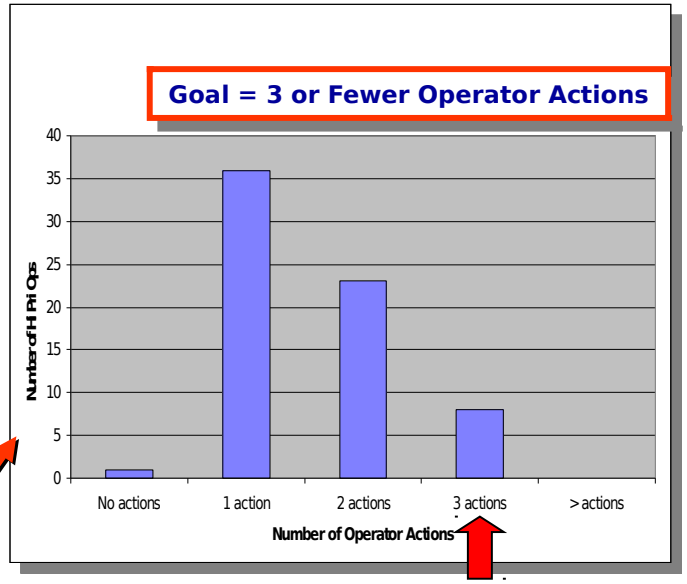

- **Reduced workload**
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USI Goals vs. Results

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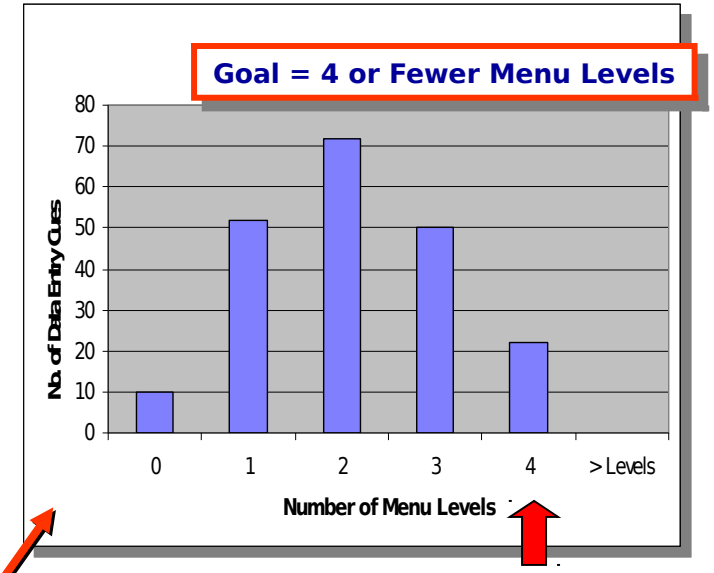

- **Reduced workload**
- **Enhanced system SA**

USI Goals vs. Results

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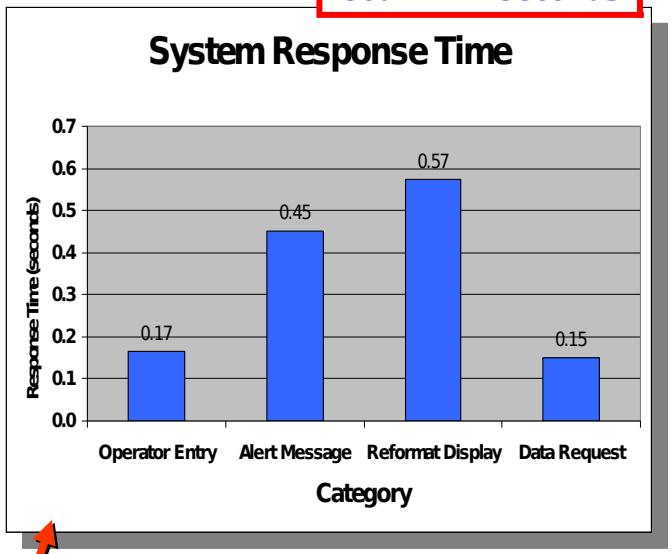
Goal= < 2 Seconds



- **Enhanced system responsiven**
- **Enhanced operator confidence**
- **Reduced operator frustration**

Summary

- Good HSI / IS collaboration results in high quality USI products (both functionality and usefulness), high customer acceptance and reduced cost.

- Early agreement on verifiable requirements & USI Standards is critical.
- User-System Interface Standard (USIS) adherence is essential.

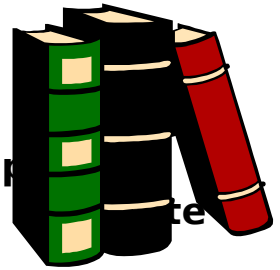
- Rigorous CM of USI designs prevents “churning” and “creeping featurism.” (controls costs)

- End-Users opinion & inputs (not design direction) are an essential / integral part of USI development and assessment.

- Lessons learned should be applied to future large scale, information- based system development integration efforts.

Back-Up Slides

Step #1
Develop Preliminary Concepts



- **Understand Requirements**
  - Task Team Derives Requirements from SFDD and the SRS
  - All requirements (not just USI) briefed at Functional Work Group meetings to ensure that requirements are relevant, accurate & complete
- **Follow Guidance in the USIS**
  - Standards Derived From User System Interface Specification for Defense Information Infrastructure (“DII”), Human Factors Principles, MIL-STD-1472, and Lessons Learned From the Previous System
  - Discuss With HF/USI As Needed
- **Brainstorm Ideas**
  - Task Teams Develop USI Concepts
  - Consult with USI Group or Make Informational Brief to USIFWG if Desired
  - Use approved GUI builder forGUI
  - These Become Paper/Static GUI “Prototypes” (Still Really Just Concepts)
  - Complete the USI Design Checklist, as appropriate
  - Configuration Control USI Artifacts

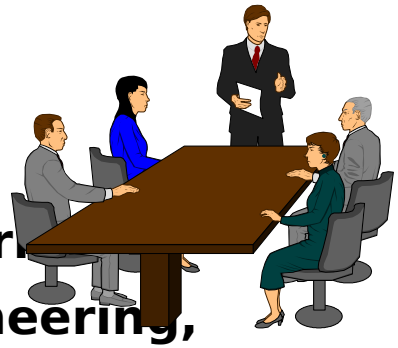
BACK-UP CHART

Step #2
Coordinate Concepts Internally

- **Review and Refine USI Concepts**
  - Task Team schedules concept review with the USI DCT
  - Task Team/Station Coordinator briefs the USI DCT (Iterate as required)
    - Requirements/Functions Summary
    - Mini-Scenario Summary
    - General Description of USI Operation
    - Step-By-Step Operation of the USI
- **Main Criteria During This Coordination Stage**
  - Compliant with USI Standard (USIS)
  - Consistent With the Rest of SMCS
  - User-Friendly - Intuitive For Operational Crews
  - Technically Feasible - Within Software/Hardware Estimates
- **When complete,**
  - Update USI Briefing
  - Post Briefing on USI Web Page
  - Configuration Control USI Artifacts

BACK-UP CHART

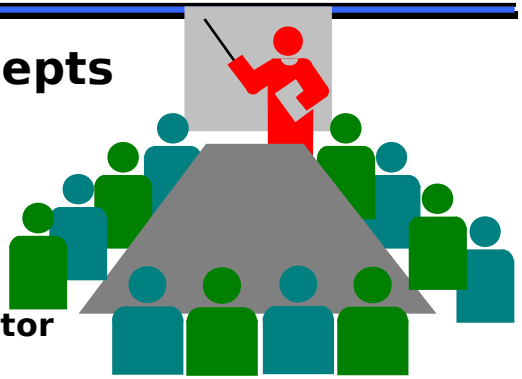
Step #3
Coordinate Concepts Externally



- **Review Concepts with End Users**
  - **Provide in-depth, informal briefings**
  - **Illustrate USI using multiple, realistic scenari**
  - **Participants include HFE/USI, Systems Engineering, Product Experts, SW Developers & others as necessary**
  - **Answer questions, take informal actions**
  - **Provide follow-up to gain closure on all open issues**
  - **Incorporate end user feedback into USI briefing (typically within two weeks)**
  - **Schedule presentation for next USI Functional Working Group**
  - **Place USI artifacts under configuration control**
  - **Move ahead only after end users are satisfied with the design**

BACK-UP CHART

Step #4
Review & Approve Concepts



- **USI Functional Work Group Reviews Design Concepts**
  - **Review By End Users and Other Customers**
  - **Station Coordinator/Task Team Presents:**
    - **Requirements, Functionality, Mission Context, USI Overview**
    - **Screens Organized In Step-By-Step Order Of Use By The Operator**
  - **Possible Outcomes:**
    - **Concur with Preliminary Design; No More Prototype Evaluations; Proceed With Design**
    - **Preliminary Design Acceptable With Mods; Return to DCT (and USI FWG If Necessary)**
    - **Preliminary Design Not Agreed To; Modifications Suggested; Return to DCT (and USI FWG When Ready)**
    - **Preliminary Design Approved in Principle; Prototype Evaluation required before proceeding with design; Potential for Mods based on results**
  - **Bottom Line: At this stage, USI FWG determines next step and is focal point of the development process**
  - **Configuration Control USI Artifacts - Release When Approved**

BACK-UP CHART

Step #4 (Continued)
Conduct Prototype Evaluation

- **Task Team Schedules Lab to Evaluate Interactive USI Prototypes**
  - Task Team Uses Common Scenario To Ensure Consistency of Results
  - Each Operator Evaluates Prototype Individually
  - Human Factors Questionnaire(s) is Completed
    - Mainly Subjective Measures
    - Objective Measures Possibly As Determined By Use Case
  - Operators Allowed “Free Play” Within Limits of the Prototype
    - Subjective Evaluation
  - End Users Provide Consensus After Formal Group Debriefing

- **Task Team/ Product expert brief results to USI FWG**
  - Results (Questionnaire, End User Comments) Briefed With Closure
  - Recommendations For Modifications to the Prototype

BACK-UP CHART

Step #5
Test & Evaluation

- **Low-Level Testing – IS Engineer tests functionality of window components, links between windows, etc. (IS)**

- **Formal USI Testing - HSI Team Uses Approved Scenario to Test USI per Requirements (e.g., SOW / USIS) (HSI)**
  - **HS Operator Evaluates Functionality/Designs per Test Plan**
  - **Human Factors Questionnaire Is Completed**
  - **Objective Measures As appropriate**

- **Scenario – Based Test and Evaluation (HS, IS, End-User)**
  - **Operators Allowed "Free Play" Within Limits of the realistic, comprehensive scenario**
    - **Subjective Evaluation**
  - **End-Users Provide Consensus After Formal Group Debriefing**

BACK-UP CHART